Geostationary Operational Environmental Satellite (GOES)

GOES-R Series

GOES-R Reliable Data Delivery Protocol (GRDDP)

January 30, 2007

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

Geostationary Operational Environmental Satellite (GOES)

GOES-R Series

GOES-R Reliable Data Delivery Protocol (GRDDP)

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GRDDP

417-R-RPT-0050, RM Version, GOES-R Reliable Data Delivery Protocol (GRDDP)

Version: 2.0
Printed by: jhendershot
Printed on: Tuesday, April 03, 2007

No filter applied.

No sort applied.

Generated from DOORS
8.1.0.6

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ID	Object Number	417-R-RPT-0050, RM Version, GOES-R Reliable Data Delivery Protocol (GRDDP)
GRDDP1	1	# 1 Introduction
GRDDP2	1.0-1	The GOES-R spacecraft uses European Cooperation for Space Standardization (ECSS) SpaceWire for the transfer of sensor, telemetry, and command data between instruments and the spacecraft. The GOES-R Program has directed that all data transferred over SpaceWire implement a reliable data delivery protocol. The SpaceWire Standard does not specify a protocol for reliable data delivery. It is the purpose of this document to specify a reliable data delivery protocol for the GOES-R spacecraft and instruments.
GRDDP3	1.1	## 1.1 Scope
GRDDP4	1.1.0-1	The Reliable Data Delivery Protocol uses the lower level SpaceWire data link layer to provide reliable packet delivery services to one or more higher level host application processes.
GRDDP6	1.1.0-2	This document specifies the functional requirements for the Reliable Data Delivery Protocol service. This document does not specify the interfaces to the lower or higher level processes, which may be implementation dependent.

ID	Object Number	417-R-RPT-0050, RM Version, GOES-R Reliable Data Delivery Protocol (GRDDP)
GRDDP7	2	**2 Reference Document**
GRDDP8	2.0-1	The lower layer protocol definitions for the GOES-R instrument to spacecraft data bus are compliant with EUROPEAN COOPERATION FOR SPACE STANDARDIZATION SpaceWire - Links, Nodes, Routers and Networks ECSS-E-50-12A, 24 January 2003.

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GRDDP9 3

3 Definitions

GRDDP10 3.0-1

Transmitter: An electronic circuit that transmits signals over a physical medium.

Receiver: An electronic circuit that receives signals over a physical medium.

SpaceWire Port: SpaceWire transmitter and receiver circuits and associated logic that implements the SpaceWire Exchange level protocol including link initialization, character flow control, and link error detection and recovery.

SpaceWire Link: A bidirectional point-to-point connection between two SpaceWire ports.

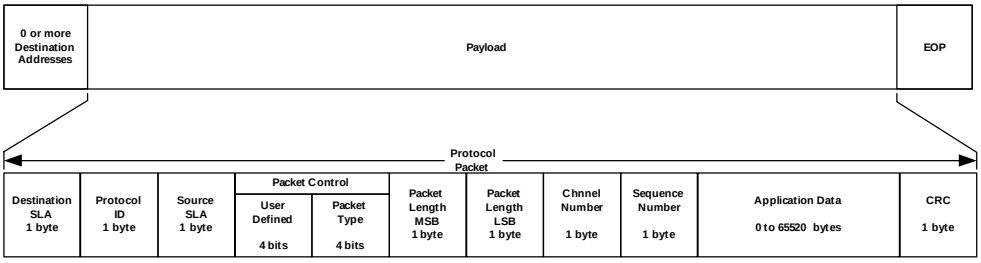
Transport End Point: A Transport End Point (TEP) is defined on a host system for the purpose of either transmitting or receiving application packets over a SpaceWire Link. Multiple TEPs can be defined for any host system, but each TEP can only transmit or receive not both.

Transport Channel: A protocol defined data path between two TEPs. A Transport Channel can exist only between one transmit TEP and one receive TEP. Each Transport Channel is a one-way data path for application packets. The protocol supports multiple concurrent Transport Channels over a SpaceWire Link.

ID	Object Number	417-R-RPT-0050, RM Version, GOES-R Reliable Data Delivery Protocol (GRDDP)
GRDDP11	4	# 4 Overall Functional Description
GRDDP12	4.0-1	This protocol describes the mechanism for reliable transfer of data packets over a SpaceWire connection (providing services through the exchange and packet layers). This protocol adds the following capabilities to a SpaceWire link: a) Multiplexed Logical Connections b) Reliable Delivery c) Missing packet detection d) Out of sequence packet reordering
GRDDP13	4.1	## 4.1 Multiplexed Logical Channels
GRDDP14	4.1.0-1	The protocol **shall** support multiple simultaneous logical connections over a single SpaceWire link.
GRDDP15	4.1.1	### 4.1.1 Channel Independence
GRDDP16	4.1.1.0-1	Each Transport channel **shall** operate independently from other transport channels.
GRDDP17	4.1.2	### 4.1.2 Transmit Priority
GRDDP18	4.1.2.0-1	When more than one packet is available for transmit, all Acknowledge packets **shall** be transmitted first, then Reset Command packets, then Urgent Message packets, then Retransmit packets, then Data packets.
GRDDP19	4.1.3	### 4.1.3 Data Transmit Queue
GRDDP20	4.1.3.0-1	When data packets from more than one channel are available for transmit, packets **shall** be transmitted in the order in which they are queued.
GRDDP21	4.1.4	### 4.1.4 Urgent Message Transmit Queue
GRDDP22	4.1.4.0-1	When Urgent Message packets from more than one channel are available for transmit, packets **shall** be transmitted in the order in which they are queued.
GRDDP23	4.2	## 4.2 Reliable Delivery
GRDDP24	4.2.0-1	The Reliable Delivery protocol detects lost packets, duplicate packets, out of sequence packets, and provides damaged data recovery. The protocol provides additional error detection beyond the SpaceWire physical layer utilizing CRCs, packet sequence numbers, positive acknowledgement, and timeouts to detect lost or duplicated Data packets.
GRDDP25	4.2.1	### 4.2.1 Error Detection
GRDDP26	4.2.1.0-1	Packet errors **shall** be detected by adding a Cyclic Redundancy Check (CRC) to each packet transmitted, checking it at the receiver, and discarding any erroneous packet.
GRDDP27	4.2.2	### 4.2.2 Packet Sequence Numbers
GRDDP28	4.2.2.0-1	An 8 bit sequence number **shall** be assigned to each packet transmitted.
GRDDP29	4.2.3	### 4.2.3 Sequence Number Use
GRDDP30	4.2.3.0-1	At the receiver the sequence numbers **shall** be used to detect lost Data, duplicate packets and to correctly order packets.

ID	Object Number	417-R-RPT-0050, RM Version, GOES-R Reliable Data Delivery Protocol (GRDDP)
GRDDP31	4.2.4	**4.2.4 Acknowledgement and Retransmit**
GRDDP32	4.2.4.0-1	The receiver **shall** send a positive acknowledgment (ACK) for each data packet received without error.
GRDDP33	4.2.5	**4.2.5 Retransmission**
GRDDP34	4.2.5.0-1	If the ACK is not received within a defined channel-specific timeout interval the data **shall** be retransmitted as defined in GRDDP120 [7.5].

ID	Object Number	417-R-RPT-0050, RM Version, GOES-R Reliable Data Delivery Protocol (GRDDP)
GRDDP35	5	# 5 Packet Format
GRDDP36	5.0-1	All protocol packets include a 48-byte header, followed by a variable length payload, followed by a 1-byte CRC. The figure below shows how the protocol packet is encapsulated within the standard SpaceWire packet. Note that while a SpaceWire packet may have zero or more destination addresses before the payload, the Reliable Delivery Protocol requires that exactly one destination address is delivered to the protocol logic.



A GRDDP Packet within a SpaceWire Packet Figure
(CCR 00354)

GRDDP37	5.1	## 5.1 Header
GRDDP38	5.1.1	### 5.1.1 Destination Address
GRDDP39	5.1.1.0-1	The first byte of the header **shall** be the Destination Address which is a one byte SpaceWire Logical Address (SLA). The SLA identifies the remote TEP to which the packet is being sent.
GRDDP40	5.1.2	### 5.1.2 Protocol ID
GRDDP41	5.1.2.0-1	The second byte of the header **shall** be decimal 238 as assigned by the ECSS. *(CCR 00354)*
GRDDP42	5.1.3	### 5.1.3 Source Address
GRDDP43	5.1.3.0-1	The third byte of the header **shall** be the Source Address which is a one byte SpaceWire Logical Address (SLA). The source address identifies the node from which a packet is sent.
GRDDP44	5.1.4	### 5.1.4 Packet Control
GRDDP45	5.1.4.0-1	The fourth byte of the header **shall** contain packet control data.
GRDDP46	5.1.4.1	#### 5.1.4.1 User Defined Bits
GRDDP47	5.1.4.1.0-1	The most significant nibble of the Packet Control byte **shall** be set to all zeros unless a program using this protocol defines them, in a program specific document, for purposes beyond the scope of this document. Note: For example, a program may define these bits as a sub-PID to identify the payload data to a higher level process.
GRDDP49	5.1.4.2	#### 5.1.4.2 Packet Type
GRDDP50	5.1.4.2.0-1	The least significant nibble of the Packet Control byte **shall** identify packet type as listed in the Packet Type Values Table below.

ID	Object Number	417-R-RPT-0050, RM Version, GOES-R Reliable Data Delivery Protocol (GRDDP)

GRDDP50 5.1.4.2.0-1

Packet Type	Value
Application	0
Acknowledge	1
Reset Command	2
Urgent Message Application	3
Reserved/User defined	4 to 15

Packet Type Values Table

GRDDP51 5.1.5

5.1.5 Application Payload Length MSB

GRDDP52 5.1.5.0-1

The fifth header byte **shall** contain the most significant byte of the Application Payload byte length field.

GRDDP53 5.1.6

5.1.6 Application Payload Length LSB

GRDDP54 5.1.6.0-1

The sixth header byte **shall** contain the least significant byte of the Application Payload byte length field.

GRDDP55 5.1.7

5.1.7 Channel Number

GRDDP56 5.1.7.0-1

The seventh header byte **shall** define the Transport Channel within which the packet is being sent.

GRDDP57 5.1.8

5.1.8 Sequence Number

GRDDP58 5.1.8.0-1

The eighth byte of the header **shall** be a sequence number in the range 0 through 255. It is recommended that the sequence number be twice the window size. *(CCR 00354)*

GRDDP59 5.2

5.2 Application Payload

GRDDP60 5.2.1

5.2.1 Data Packets and Urgent Messages

GRDDP61 5.2.1.0-1

The protocol Data packets and Urgent Message Packets **shall** contain an Application Payload field containing 1 to 65520 (inclusive) bytes of content for delivery to the Application Level client associated with the channel's Receive TEP.

GRDDP62 5.2.2

5.2.2 Acknowledge and Reset Packets

GRDDP63 5.2.2.0-1

Protocol packets that are an Acknowledge or Reset Command **shall** contain a zero length Application Payload field.

GRDDP64 5.3

5.3 Trailer

GRDDP65 5.3.0-1

The protocol packet trailer **shall** be an 8 bit Asynchronous Transfer Code (ATM) Cyclic Redundancy Check (CRC) computed from the transport header destination SLA to the last payload byte, defined in the following polynomial:

CRC8, ATM (HEC)

$$x^8 + x^2 + x + 1$$

GRDDP66 5.3.1

5.3.1 CRC Preset

GRDDP67 5.3.1.0-1

Prior to computing each packet's CRC, the initial value for the computation **shall** be set to all 1s.

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GRDDP68 6

6 Transport Channel Definition

GRDDP69 6.0-1

The set of available Transport Channels for each host system **shall** be pre-defined in protocol configuration tables.

GRDDP70 6.1

6.1 TEP Parameters

GRDDP71 6.1.0-1

Each TEP **shall** be defined with the following parameters:

Local SLA Number	A SpaceWire Logical Address (SLA) assigned to the Local SpaceWire Node.
Remote SLA	The SLA of the SpaceWire Node hosting the Remote TEP to which the Local TEP is connected.
TEP Type	Identifies the TEP as transmit or receive.
Channel Number	A subset of addresses within a TEP used to communicate with components contained in a subassembly as and example.
Window Size	The size of the channel's sequence number window. This value must be a power of two.
Time Out	Transmit TEPs only. The time to wait to receive an acknowledge before retransmitting a data packet.
Maximum Retries	Transmit TEPs only. The number of retry attempts allowed before declaring a SpaceWire link failure.

GRDDP72 6.2

6.2 TEP States

GRDDP73 6.2.0-1

Each TEP **shall** be in one of three possible operating states:

Closed	The TEP does not generate any packets on the link and does not respond to any packets received.
Enabled	A TEP transitions to the "Enabled" state when the host has requested it to be opened, and provided appropriate I/O buffer information. In addition, a Transmit TEP sends a reset command on this transition.
Open	A Receive TEP transitions from Enabled to Open when a Reset command has been received from the remote Transmit channel. A Transmit TEP transitions from Enabled to Open when it receives an ACK for a Reset command that it has sent to the remote Receive TEP.

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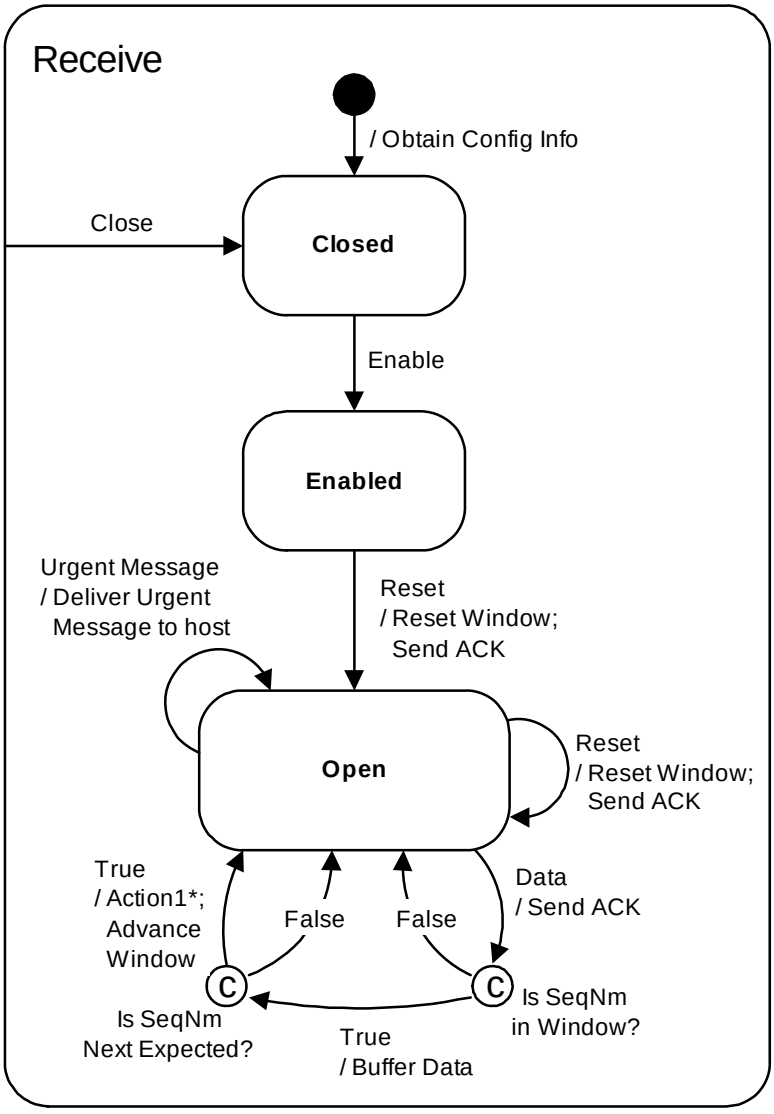
GRDDP74	7	# 7 Channel Operations
GRDDP75	7.1	## 7.1 Logical Connections
GRDDP76	7.1.0-1	Upon power up initialization all TEPs **shall** be in the Closed state.
GRDDP77	7.2	## 7.2 Reset Command
GRDDP78	7.2.0-1	When a Transmit TEP transitions to the Enabled state, it **shall** send a Reset command to its remote Receive TEP and initiate an acknowledgement timer.
GRDDP79	7.2.1	### 7.2.1 Reset Timer Cancellation
GRDDP80	7.2.1.0-1	Upon receipt of a Reset acknowledgement, the transmit TEP **shall** cancel the acknowledgement timer.
GRDDP81	7.2.2	### 7.2.2 Reset Timer Expiration
GRDDP82	7.2.2.0-1	Upon expiration of the Reset timer period, the transmit TEP **shall** retransmit the Reset command.
GRDDP83	7.3	## 7.3 Transport Channel Connection
GRDDP84	7.3.0-1	A Transport Channel connection **shall** be considered established when a Transmit TEP and Receive TEP are both in the Open state.
GRDDP85	7.4	## 7.4 Receive TEP Operations
GRDDP86	7.4.1	### 7.4.1 Receive TEP Data Packet
GRDDP87	7.4.1.0-1	A receive TEP **shall** not send a data packet.
GRDDP88	7.4.2	### 7.4.2 Receive TEP Urgent Messages
GRDDP89	7.4.2.0-1	A receive TEP **shall** not send an Urgent Message packet.
GRDDP90	7.4.3	### 7.4.3 Receive TEP Reset Command
GRDDP91	7.4.3.0-1	A receive TEP **shall** not send a reset command.
GRDDP92	7.4.4	### 7.4.4 Sliding Window
GRDDP93	7.4.4.0-1	The receive TEP **shall** maintain a sliding window which is a range of consecutive sequence numbers to determine whether each received data packet will be accepted or discarded.
GRDDP94	7.4.5	### 7.4.5 Sliding Window Range
GRDDP95	7.4.5.0-1	The receive window range **shall** start with the sequence number of the next data packet expected to be delivered and end with sequence number equal to the start plus Window Size minus 1.
GRDDP96	7.4.6	### 7.4.6 Window Advance

ID	Object Number	417-R-RPT-0050, RM Version, GOES-R Reliable Data Delivery Protocol (GRDDP)
GRDDP97	7.4.6.0-1	The receive window **shall** be advanced by 1 upon receipt of a packet containing the next expected sequence number. Note: If packets with successively adjacent sequence numbers have already been received out of order, the start of the receive window will be advanced by more than 1, plus the number of successively adjacent "early" packets.
GRDDP98	7.4.7	**7.4.7 Packet Acknowledgement**
GRDDP99	7.4.7.0-1	All Data and Reset Command packets received without error **shall** be acknowledged.
GRDDP100	7.4.8	**7.4.8 Packets with Errors**
GRDDP101	7.4.8.0-1	Any packet received with detectable errors **shall** be discarded and not acknowledged.
GRDDP102	7.4.9	**7.4.9 Out of Window Sequence Number**
GRDDP103	7.4.9.0-1	A data packet that is received with a sequence number that is not within the receive window **shall** be acknowledged, but discarded.
GRDDP104	7.4.10	**7.4.10 Duplicate Sequence Number**
GRDDP105	7.4.10.0-1	A data packet received with a sequence number within the receive window that is a duplicate of a packet pending delivery to the host **shall** be acknowledged, but discarded.
GRDDP106	7.4.11	**7.4.11 Urgent Message Acknowledgement**
GRDDP107	7.4.11.0-1	Urgent Message packets **shall** not be acknowledged.
GRDDP108	7.4.12	**7.4.12 Urgent Message Delivery Order**
GRDDP109	7.4.12.0-1	Urgent Message packets **shall** be delivered to the host in the order received. The sequence number is not used in Urgent Message packets.
GRDDP110	7.4.13	**7.4.13 Urgent Message Delivery Priority**
GRDDP111	7.4.13.0-1	Urgent Message packets **shall** be delivered to the host before any Data Packets pending delivery.
GRDDP112	7.4.14	**7.4.14 Reset Command Sequence Number**
GRDDP113	7.4.14.0-1	A Reset command that does not have a sequence number of zero **shall** be treated as an error packet.
GRDDP114	7.4.15	**7.4.15 Reset Command Processing**
GRDDP115	7.4.15.0-1	When a Reset command is received, the receive window start **shall** be set to 1.
GRDDP116	7.4.16	**7.4.16 Packets Pending Delivery**
GRDDP117	7.4.16.0-1	When a Reset command is received all packets pending delivery to the host **shall** be discarded.
GRDDP118	7.4.17	**7.4.17 Reset Command Report**
GRDDP119	7.4.17.0-1	Receipt of a reset command **shall** be reported to the host.
GRDDP120	7.5	**7.5 Transmit TEP Operations**

ID	Object Number	417-R-RPT-0050, RM Version, GOES-R Reliable Data Delivery Protocol (GRDDP)
GRDDP121	7.5.1	**7.5.1 Transmit TEP ACKs**
GRDDP122	7.5.1.0-1	A transmit TEP **shall** not send an ACK packet.
GRDDP123	7.5.2	**7.5.2 Transmit TEP Sequence Number Allocation**
GRDDP124	7.5.2.0-1	Each data packet transmitted **shall** have a sequence number allocated from the TEP's transmit window range of available sequence numbers.
GRDDP125	7.5.3	**7.5.3 Reset Command Sequence Number**
GRDDP126	7.5.3.0-1	All Reset commands **shall** be transmitted with a sequence number zero.
GRDDP127	7.5.4	**7.5.4 Transmit Window**
GRDDP128	7.5.4.0-1	A transmit TEP **shall** maintain a sliding window range of consecutive sequence numbers that are available for transmitting data packets.
GRDDP129	7.5.5	**7.5.5 Unacknowledged Packets**
GRDDP130	7.5.5.0-1	The transmit window **shall** limit the number of unacknowledged data packets that can be transmitted.
GRDDP131	7.5.6	**7.5.6 Transmit Window Start**
GRDDP132	7.5.6.0-1	The transmit window start **shall** be set to 1 when an ACK is received for a Reset command.
GRDDP133	7.5.7	**7.5.7 Transmit Window Advance**
GRDDP134	7.5.7.0-1	The transmit window start **shall** be advanced by 1 when the ACK is received for the first sequence number in the transmit window. Note: Similar to the case of advancing the Receive Window, out-of-order acknowledgements may require the Transmit Window to be advanced by more than 1 (1 plus the number of successively adjacent “early” acknowledgements).
GRDDP136	7.5.8	**7.5.8 Packet Retransmit**
GRDDP137	7.5.8.0-1	A transmitted data packet that is not acknowledged within a defined, channel specific timeout interval **shall** be retransmitted with the original sequence number up to a channel specific number of times.
GRDDP138	7.5.9	**7.5.9 Retry Reset**
GRDDP139	7.5.9.0-1	When a channel specific number of retry attempts have been exceeded the channel **shall** be reset.
GRDDP140	7.5.10	**7.5.10 Timeout Start**
GRDDP141	7.5.10.0-1	The timeout interval **shall** begin when the last byte of the Data Packet or Reset Command has been transmitted.
GRDDP152	7.5.11	**7.5.11 Urgent Message Transmission**
GRDDP153	7.5.11.0-1	Urgent Message Packets **shall** be sent immediately without being allocated a transmit window sequence number or starting an acknowledgement timer. Note that Urgent Message Packets are sent once without retries or acknowledgements.

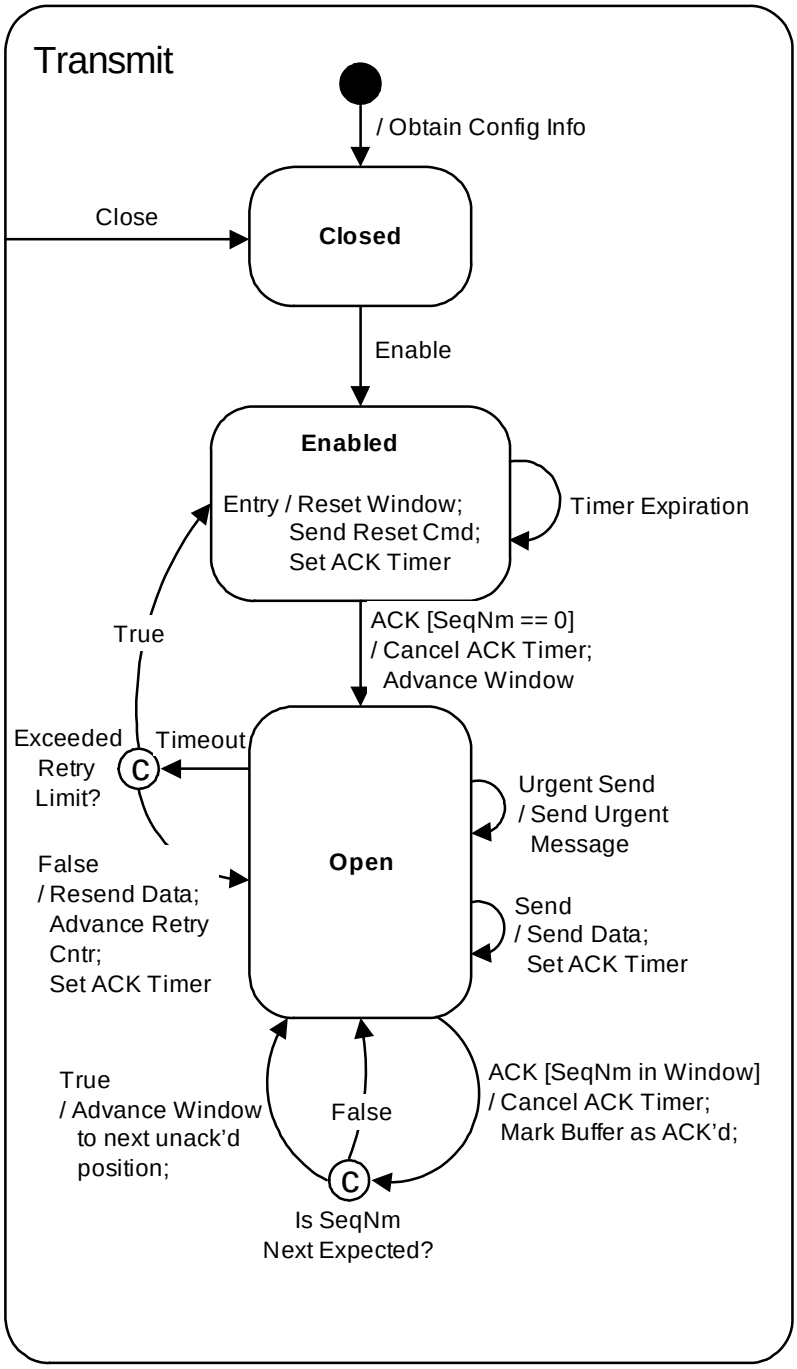
ID	Object Number	417-R-RPT-0050, RM Version, GOES-R Reliable Data Delivery Protocol (GRDDP)
GRDDP154	8	**8 State Diagrams - Information Only**
GRDDP156	8.0-1	



*Action1: Deliver Data and any previously received successively numbered message in Window to host in sequence number order

Receive TEP State Transition Diagram

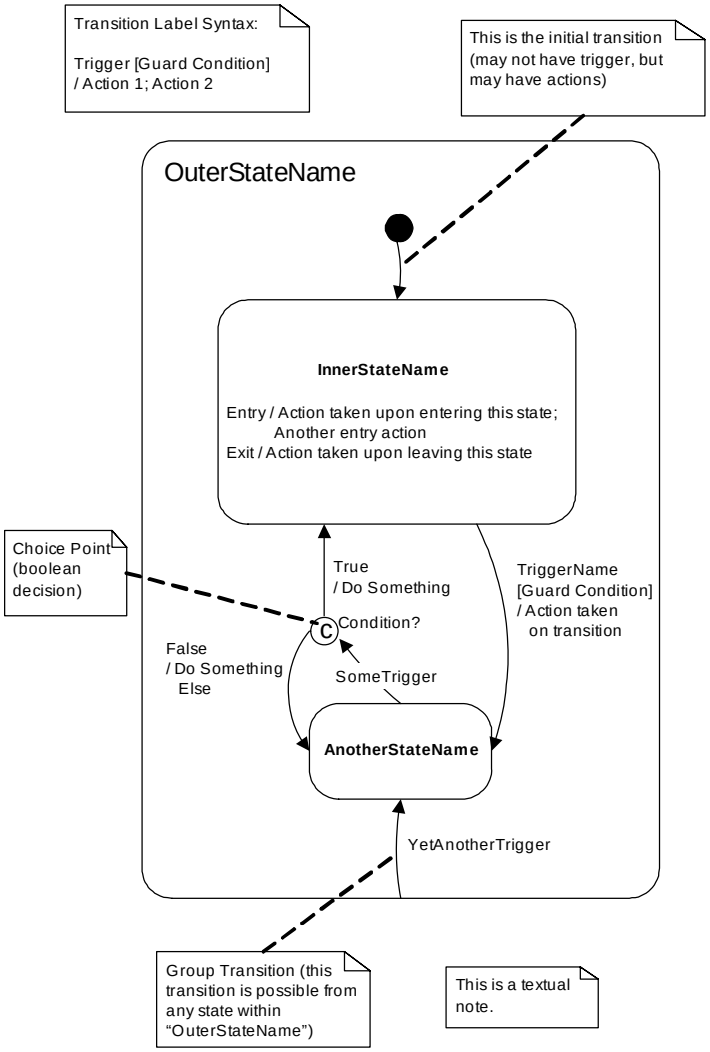
ID	Object Number	417-R-RPT-0050, RM Version, GOES-R Reliable Data Delivery Protocol (GRDDP)
GRDDP156	8.0-1	



Transmit TEP State Transition Diagram

ID	Object Number	417-R-RPT-0050, RM Version, GOES-R Reliable Data Delivery Protocol (GRDDP)

GRDDP156 8.0-1



State Transition Diagram Legend

ID	Object Number	417-R-RPT-0050, RM Version, GOES-R Reliable Data Delivery Protocol (GRDDP)
GRDDP155	9	
GRDDP157	9.0-1	

9 Acronyms

ACK	Acknowledgment
ATM	Asynchronous Transfer Mode
CRC	Cyclic Redundancy Check
ECSS	European Cooperation for Space Standardization
GOES	Geostationary Operational Environmental Satellite
GOES-R	Geostationary Operational Environmental Satellite -R Series
GRDDP	GOES-R Reliable Data Delivery Protocol
GSFC	Goddard Space Flight Center
HEC	Header Error Code
ID	Identification
NASA	National Aeronautics and Space Administration
SLA	SpaceWire Logical Address
TEP	Transport End Point

417-R-RPT-0050 DCR

CCR #: 00106 Rev **Title: GOES-R Reliable Data Delivery Protocol**
Contract # NNG0 - 4HZ07C GOES S/C: R Effectivity: S/C & Instruments
CCB Status: **Approved** Doc #: 417-R-RPT-0050 Rev-A
CCB Date: 7/8/2005 Doc Section All
Contract Mod#: **ABI 020** DOORS Version: N/A
Doc Change: 7/1/2005 DOORS ID #: N/A

CCR #: 00216 Rev **Title: GOES-R GRDDP Revision**
Contract # NNG0 - 4HZ07C, 6HX01C Info 4HZ48C, 4HZ49C, 4HZ50C, 4HZ65C, 6HX11C, 6HX12C, 6HX13C, GOES S/C: R Effectivity: SC & Instruments
Doc #: 417-R-RPT-0050 Rev-B
CCB Status: **Approved**
CCB Date: 4/28/2006 Doc Section All
Contract Mod#: **ABI 038, ATC 004** DOORS Version:
Doc Change: 4/28/2006 DOORS ID #: N/A

CCR #: 00354 Rev **Title: GRDDP Update**
Contract # NNG0 - 4HZ07C, 6HX01C, Info 4HZ48C, 4HZ49C, 4HZ50C, 6HX11C, 6HX12C, 6HX13C, SUVI/EXIS GOES S/C: R Effectivity: S/C & Instruments
Doc #: 417-R-RPT-0050
CCB Status: **Approved**
CCB Date: 1/30/2007 Doc Section 1.1, 2, 5.1.2, 5.1.8, 7.5.11
Contract Mod#: **ATC 004, ITT 061** DOORS Version: N/A
Doc Change: 1/30/2007 DOORS ID #: N/A